EUROPEAN CENTRAL BANK
EUROSYSTEM

Working Paper Series

Desislava Andreeva, Anna Samarina,
Lara Sousa Faria

Leverage actually: the impact on banks' borrowing costs in euro area money markets

No 3016

Abstract

This paper explores the impact of the regulatory leverage ratio (LR) on banks' demand for reserves and thus the pricing of overnight liquidity in the euro area money markets. We use daily transaction-level money market data during the period between January 2017 - February 2023 and examine the two major overnight money market segments – the unsecured and the secured one, distinguishing between over-the-counter (OTC) and CCP-cleared trades for the latter. We find a significant positive link between a bank's LR and the spread between its money market borrowing rate and the DFR. Banks with a higher LR offer deposits at higher interest rates, thereby reducing the markdown vis-à-vis the DFR. The impact of the LR dampens during the period in which central bank reserves did not count towards the LR exposure measure (or the denominator of the ratio). It is stronger for G-SIBs, who need to comply with a G-SIB LR add-on on top of the minimum requirement applicable to all euro area banks. Moreover, the impact is weaker for CCP-cleared transactions compared to OTC trades, likely reflecting the possibility to net bilateral exposures if cleared via CCPs, which effectively allows banks to finance the respective gross money market exposures with a smaller share of Tier 1 capital.

Keywords: leverage ratio, money markets, €STR, bank balance sheet constraints

JEL-Codes: G12, G21, G28

Non-technical summary

The Global Financial Crisis revealed several important weaknesses in the regulatory and supervisory framework for banks. The subsequent strengthening of these frameworks involved among others, the introduction of a leverage ratio (LR) requirement, set at a minimum of 3% of banks' exposures. The regulatory LR affects banks' willingness to intermediate in money markets. It introduces an implicit balance sheet cost of holding central bank reserves because it requires banks to partly fund them using Tier 1 capital, which is significantly more expensive than debt. In the current environment of ample reserves, some large banks acquire significant amounts of liquidity via money markets, subsequently placing it on the Eurosystem's deposit facility. Such intermediation of liquidity storage expands banks' balance sheets, lowering their reported regulatory LR. As a result, the LR requirement reduces banks' willingness to hold reserves, particularly (but not only) on reporting dates, typically at quarter- and year-ends.[1] Around these days banks tend to "window-dress" their balance sheets by shrinking their reserve holdings. They do so by temporarily reducing overnight money market borrowing, which pushes money market rates down and manifests in sharp downward spikes in rates. This may cause volatility in demand for reserves at reporting dates and a widening of the spread between short-term money market rates and the ECB's deposit facility rate (DFR), with potential implications for monetary transmission.

This paper examines the impact of the LR requirement on the pricing at which euro area banks acquire reserves in the euro area money markets, using daily transaction-level MMSR (money market statistical reporting) data from January 2017 until February 2023. We apply a panel multi-level fixed effects regression estimation for each of the three overnight segments – unsecured, secured over-the-counter (OTC), and secured CCP-cleared. In addition to the direct impact of the LR, we analyse conditioning factors, such as the exemption of central bank reserves from the LR exposure measure during the pandemic, and document the differences in the impact of the LR across bank types, segments of the money market, and in relation to the proximity of banks to the regulatory minimum.

[1] The year-end effect tends to be stronger due to fees and levies (e.g. contribution to deposit insurance and resolution funds) which are determined once a year, based on the overall balance sheet size of banks.

Our findings confirm the existence of a significant positive link between the bank's LR and the money market interest rate spread in the unsecured and secured OTC segments. That is, banks with a higher LR offer higher deposit rates to customers, thereby reducing – in absolute terms - the (negative) spread with the DFR. This finding is in line with the economic intuition. Banks require an intermediation spread for accepting money market deposits and storing these on the deposit facility. The spread compensates banks – among other factors – for binding balance sheet capacity for that purpose instead of alternative uses. The scarcer balance sheet capacity is, the higher is the intermediation spread that banks request. In line with this intuition, we find evidence of non-linear effects: the impact of the LR on money market spreads is stronger for banks with a LR in the vicinity of the regulatory minimum. In terms of the economic size, a one standard deviation increase in bank's LR is associated with a higher (un)secured rate spread by about 0.9-1.1 basis point.

We document a consistent pattern of weaker effects of the LR for periods of time, banks or segments of the money market that effectively feature a less stringent requirement. First, the LR exemption for central bank reserves during the pandemic significantly dampened the impact of the LR on spreads. Second, the effect of the LR on the money market interest rate spreads is stronger for G-SIBs, which need to comply with an add-on on top of the minimum requirement. And finally, the impact of the LR on the pricing of CCP-cleared transactions is weaker compared to otherwise similar OTC trades, likely reflecting that bilateral exposures can be netted for the purpose of the regulatory LR if cleared via CCPs. Such netting implies that banks can finance the respective gross money market exposures with a smaller share of Tier 1 capital.

Our findings are informative also from a policy perspective. First, they confirm that regulatory measures such as the LR can have a significant impact on banks' demand for reserves, with implications for money market activity. Second, the LR exemption during the pandemic was successful in providing some relief for banks and supporting their money market intermediation role. Third, the regulatory LR may have varying effects across banks and money market segments, resulting in differences in banks' demand for reserves.

1. Introduction

The Global Financial Crisis (GFC) revealed several important weaknesses in the regulatory and supervisory framework for banks. The subsequent strengthening of these frameworks involved among others, the introduction of a leverage ratio (LR) requirement – a supplementary capital ratio against all bank exposures, including the safest and most liquid ones, set at a minimum of 3% of a bank's total assets and some of its off-balance-sheet exposures.[2] This regulatory requirement can affect banks' demand for reserves sourced in money markets.

Our paper explores the impact of the LR requirement on the pricing at which euro area banks acquire reserves in euro area money markets, using daily transaction-level money market data from January 2017 to February 2023. Apart from looking at the direct impact of the LR, we analyse several conditioning factors: the role of the temporary exemption of central bank reserves when calculating LR requirements during the pandemic, banks' distance to the minimum LR requirement, their size, and the role of netting of bilateral exposures for CCP-cleared money market trades.

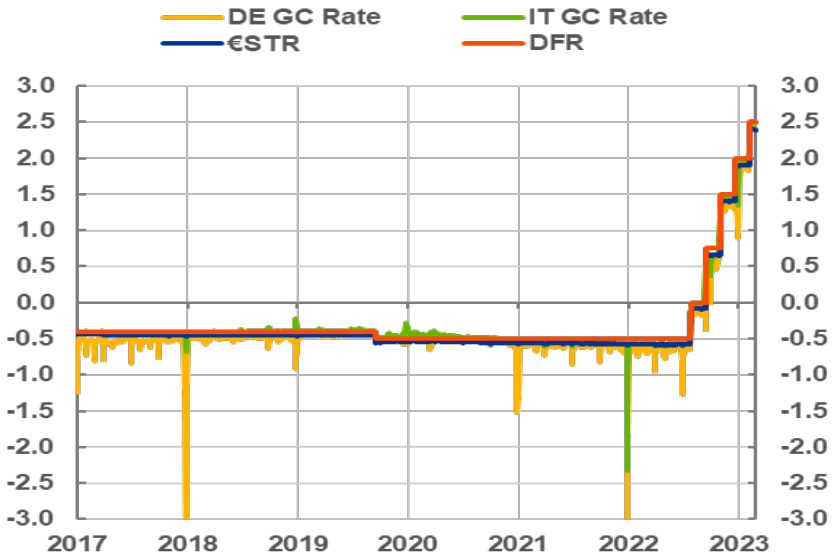
The regulatory LR lowers banks' willingness to fulfil an intermediating role in money markets. It introduces an implicit balance sheet cost of holding reserves as it requires banks to fund part of them using Tier 1 capital, which is significantly more expensive than other funding sources. In the current environment of ample reserves, some banks, typically large ones, acquire a significant share of their excess liquidity via the money market from euro area (EA) non-bank financial intermediaries and non-EA counterparties, subsequently placing it on the Eurosystem's deposit facility. Such intermediation of liquidity storage expands banks' balance sheets, effectively lowering their LR. A binding LR makes it thus costly for banks to hold liquid reserves (Acharya et al., 2022). As a result, the LR requirement reduces banks' willingness to hold reserves, particularly - but not only - on reporting dates (at quarter- and year-ends). Around these dates, banks "window-dress" their balance sheet by shrinking the reserves they hold. They do so by temporarily reducing overnight money market borrowing, which pushes money market rates down. This manifests in sharp downward spikes in rates, introducing strong seasonal effects (see Figure 1). The spikes affect most prominently the repo segment amid large volume declines, given overall more significant volumes transacted in the secured compared to the

[2] See Section 2 for the background information on the LR regulation.

unsecured money market. This may cause volatility in demand for reserves around reporting dates and a widening of the negative spread between short-term money market rates and the ECB's deposit facility rate (DFR) (see Figure 1 below and Figures A1-A2 in the Annex).

The role of regulatory constraints in driving banks' demand for and management of reserves is well recognized in the literature (see e.g., Aberg et al., 2021; Acharya et al., 2022; Afonso et al., 2022; Stulz et al., 2022). If LR requirements are binding or banks operate at a buffer vis-à-vis regulatory minima perceived as uncomfortable, they tend to shrink their reserves. Replacing loans with liquid assets does not result in an improvement of banks' LR as both are treated equally. Hence, the LR requirement induces a negative relation between equity and holdings of liquid assets (Stulz et al., 2022). Higher balance sheet costs of warehousing reserves due to regulation may also discourage interbank trading even if aggregate excess reserves shrink from their current abundant levels (Afonso et al., 2019; Kim et al., 2020).

Figure 1: Euro area money market rates (in pp.), January 2017 - February 2023



Source: MTS/Brokertec, ECB, and ECB calculations.

Notes: Rates are determined on the basis of the agreement date of relevant transactions and calculated as the volume weighted average daily rate.

Several empirical studies examine the impact of the LR regulation and banks' "window-dressing" on money market activity. Banegas and Tase (2020) find that following the public disclosure of the Basel III LR rules, European banks decreased their holdings of reserves and borrowing in the U.S. fed funds market on reporting dates relatively more compared to the U.S.

domestic banks. In a similar vein, Munyan (2017) and Anbil and Senyuz (2022) show that window-dressing in the U.S. tri-party repo market is mainly driven by European and Japanese banks required to report regulatory ratios at quarter-ends.[3] Allahrakha et al. (2018) report that the 2012 introduction of the supplementary LR disincentivized broker-dealer affiliates of bank holding companies from borrowing in the U.S. tri-party repo market, resulting in the decline in repo volumes. In addition, Kotidis and van Horen (2018) find that U.K. banks with a more binding LR offered lower rates for their smaller clients and reduced repo borrowing volumes.

Corradin et al. (2020) use transaction-level MMSR data combined with supervisory data to examine the effects of capital regulation on EA money markets. The authors find that banks closer to their regulatory LR minimum reduce their total money market borrowing at quarter-ends by up to 23%, this effect being driven by the overnight secured segment and is insignificant in the unsecured one. In addition, banks experience lower interest rates on overnight borrowing trades at quarter-ends by 7-8 bps and higher dispersion of money market rates by 5-6 bps. Bassi et al. (2024) similarly document the contraction in EA repo volumes and rates at reporting dates. They also show that banks with a relatively low LR reduce their balance sheet repo exposure at quarter- and year-ends more than banks with a relatively high LR. Additionally, Ranaldo et al. (2021) find that the new regulatory framework, including the Basel III LR, led to lower repo rates and wider rate dispersion affecting most strongly repos with a large convenience yield. In addition, banks that are counterparties of CCPs lend more in the interbank market, to offset cash surplus.

Baldo et al. (2018) show that although banks report a decrease in outstanding repos around reporting dates, the overall activity outside these dates is not substantially affected by the LR requirement. Finally, Bucalossi and Scalia (2016) and Grill et al. (2017) find that regulatory reforms did not lead to a material reduction in EA repo volumes relative to the overall size of banks' exposures. In addition, changes in repo activity depend on the LR level - banks may be inclined to adjust relatively more if they are closer to the 3% LR minimum, while banks with greater cushions exhibit more modest declines in outstanding volumes of repo transactions.

[3] Basel reporting requirements vary by jurisdiction: for U.S. banks the Basel III LR is calculated based on averages of daily values, while for European and Japanese banks it is based on quarter-end values.

Our paper contributes to the literature in several ways. First, we analyse separately the two major EA money market segments – the unsecured and secured one, for the latter distinguishing between over-the-counter (OTC) transactions and transactions that are cleared via central counterparties (CCP-cleared) – to get insights on how the LR regulation and other factors impact interest rate spreads vis-à-vis the DFR in each of them. Second, we explore the role of the LR exemption measure introduced during the pandemic, with important implications for monetary policy transmission. Third, we consider other factors that may be relevant, such as the proximity of banks' LRs to the regulatory minimum and the systemic importance of banks associated with an add-on on top of the minimum LR requirement applicable to all EA banks.

Our findings confirm the existence of a significant positive link between a bank's LR and the money market rate spreads in the unsecured and secured OTC segments. Banks with a higher LR offer higher deposit rates to customers, thereby reducing – in absolute terms - the spread to the DFR. Essentially, they charge customers a lower spread for the intermediation of storage services, arguably because the shadow cost of bank capital required to perform this type of intermediation is lower when banks operate at a LR away from the regulatory minimum. In line with this intuition, we also find evidence of non-linear effects: the impact of a LR on money market spreads is stronger for banks with a LR in vicinity of the regulatory minimum of 3%.

We document a consistent pattern of weaker effects of the LR for periods of time, banks or segments of the money market that effectively feature a less stringent requirement. First, we find evidence that the LR exemption during the pandemic significantly dampened the impact of bank's LR on spreads. As storage intermediation services in that period no longer had to be backed by scarce regulatory capital, the portion of the intermediation spread which typically compensates for that stopped affecting money market interest rates. Second, the effect of the LR on the money market interest rate spreads is stronger for G-SIBs, which need to comply with an add-on on top of the minimum LR requirement (a G-SIB add-on, see Section 2 for details). Lastly, the impact of the LR on the pricing of CCP-cleared transactions is weaker compared to otherwise similar OTC trades, likely due to the possibility to net bilateral exposures if cleared via CCPs, which implies that banks can finance the respective gross money market exposures with a (potentially significantly) smaller share of Tier 1 capital.

The rest of the paper is structured as follows. Section 2 provides background information on the LR and explains how it impacts banks' demand for liquidity. Section 3 and 4 describe the methodology and the dataset construction, respectively. Section 5 presents the main empirical results and several extensions. Section 6 concludes.

2. Leverage ratio – background and impact on banks' demand for liquidity

The regulatory LR is defined as the ratio between a capital measure (the numerator) and an exposure measure (the denominator), with this ratio expressed as a percentage. The capital measure is Tier 1 capital – comprising Common Equity Tier 1 (CET1) and Additional Tier 1 (AT1) instruments - as defined for the purposes of the Basel III risk-based capital framework.[4] A bank's total exposure measure is the sum of on-balance sheet exposures, derivative exposures, securities financing transaction exposures, and off-balance sheet items.[5] In contrast to risk-based capital requirements (i.e. the CET1, Tier 1, and total regulatory capital ratios), the amount of capital that banks need to set aside to meet LR requirements does not depend on the riskiness of banks' exposures and individual exposures are not risk-weighted when calculating the LR. Its function in the regulatory framework is supplementary: to counteract the pro-cyclical effect of risk-based capital requirements and act as a backstop, ensuring a minimum level of capital. It provides a simple and transparent measure of a bank's leverage, which refers to the extent to which a bank finances its activities through debt.

Central bank reserves are fully accounted for in the exposure measure of the LR. Therefore, the more central bank reserves a bank holds, the more Tier 1 capital is necessary to fulfil the LR requirement. De facto, the LR requirement introduces an implicit cost of holding central bank liquidity as it requires banks to partly fund these with Tier 1 capital, which is scarcer and more expensive than bank debt. As a result, banks' demand for reserves – in particular over and beyond what they would require meeting immediate payment obligations and a small safety buffer on top – is likely to depend on the distance between their reported LR and the regulatory minimum.

[4] https://www.bis.org/basel_framework/chapter/LEV/20.htm?inforce=20230101&published=20200327.
[5] https://www.bis.org/basel_framework/chapter/LEV/30.html.

The phasing-in of the LR requirement began with bank-level reporting of the LR and its components to national supervisors from 1 January 2013 and proceeded with public disclosure from 1 January 2015. The LR became binding for all banks in the EU with the introduction of the revised Capital Requirements Regulation (CRR) on 28 June 2021. However, on 17 September 2020, the ECB Banking Supervision allowed banks under its direct supervision to temporarily exclude central bank reserves from the LR in view of the exceptional circumstances due to the Covid pandemic. The measure aimed at easing the implementation of monetary policy and was extended once.[6,7] It remained in force until the end of March 2022. Since then, central bank reserves are fully accounted for in the LR exposure. While in other jurisdictions the exposure measure must be calculated as an average over daily values (e.g., in the U.S.), in the EU only quarter-end values are relevant for the calculation.

Large banks have additional reporting requirements (e.g., average values over the quarter) that limit the scope for window dressing on a large scale. Additionally, there is an add-on on the LR for G-SIBs, with the add-on set at 50% of the respective G-SIB surcharge a bank is facing in the risk-based capital framework (BIS, 2023).[8] For instance, a G-SIB subject to a 2% G-SIB surcharge is also subject to a 1% LR add-on on top of the minimum 3% requirement. This LR add-on for G-SIBs was announced on 27 March 2020 and came into force on 1 January 2023. This regulatory change may play a role for the pricing of market liquidity by G-SIBs as it effectively requires G-SIBs to fund a higher share of their reserve holdings with bank capital, increasing the implicit balance sheet cost of warehousing central bank reserves for this set of institutions.

3. Methodology

We run panel regressions with a similar structure separately for each of the three samples representing the unsecured, the secured OTC, and the secured CCP-cleared money market segments. The baseline model is specified as follows:

[6] See the initial announcement:
https://www.bankingsupervision.europa.eu/press/pr/date/2020/html/ssm.pr200917~eaa01392ca.en.html.
[7]See the extension of the temporary exemption:
https://www.bankingsupervision.europa.eu/press/pr/date/2021/html/ssm.pr210618~6cae096a27.en.html.
[8] https://www.bis.org/basel_framework/chapter/LEV/40.htm?inforce=20230101&published=20200327.

$$y_{ibjt} = \beta_1 * LR_{bq-1} + \beta_2 * (EL/TA)_t + \beta_3 * bank\_ctrl_{bt-1} + \beta_4 * VIX_t + \beta_5 * q\_end_t + \beta_6 * y\_end_t + \beta_7 * domestic_{ibjt} + \theta * segment\_ctrl_{ibjt} + \mu_b + \omega_i + \varepsilon_{ibjt}, \quad (1)$$

where y_{ibjt} denotes the spread (in bps) between the interest rate for the identified borrowing transaction *i* of a reporting bank *b* with a counterparty *j* on a trading day *t*, and the DFR. More specifically, we subtract the DFR from the transaction rate. This spread is in general negative over the sample period as overnight money market interest rates remained in the vicinity but below the DFR, see Figure 1. The intermediation margin of banks for storage services is measured by the absolute value of this spread: banks earn the DFR on their central bank accounts for liquidity sourced at a lower money market rate. An increase in the intermediation margin is visible in a more strongly negative – and thus wider – spread, if defined - as in our case - as the transaction interest rate minus the DFR.

LR_{bq-1} denotes the quarterly bank-specific LR (in percent), our main variable of interest. We would like to capture the causal effect of the regulatory LR on banks' money market borrowing interest rates. Using contemporaneous LR, however, could suffer from reverse causality as the bank's LR calculated at a particular quarter-end is endogenous to its money market borrowing activity (and with that, potentially pricing) on that trading day; higher amounts obtained lead to an increase in the denominator of the ratio. Moreover, already during the days prior to quarter-ends, banks may be adjusting their balance sheets and thus also their demand for liquidity in anticipation of the reporting moment. To address this type of endogeneity, we include the bank's LR value as of the end of the previous quarter relative to the trading day *t*. The lagged LR is by construction fully predetermined and no longer endogenous to banks' money market activities - and by extension borrowing interest rates - in the subsequent quarter, removing any reverse causality. It still captures well the main causal effect of interest for our analysis given the strong persistence of reported LRs.

The variable $(EL/TA)_t$ denotes the daily Eurosystem's aggregate excess liquidity relative to the total banking system assets (in percent), capturing the Eurosystem's supply of reserves through refinancing operations and asset purchases. Previous evidence shows that larger supply

of central bank reserves is associated with lower money market interest rates and thus a lower price for liquidity.[9]

Bank-specific control variables denoted as $bank\_ctrl_{bt-1}$ in equation (1) include lagged bank-level excess liquidity relative to the bank's total assets (in percent), lagged average unused tiering allowances (in EUR bln), and bank's total assets (in log-level). The first variable captures that banks with larger excess reserves are likely to have lower demand for additional reserves, and thus may be inclined to offer lower deposit rates to money market customers. Unused allowances control for the potential impact on money market interest rates of the Eurosystem's two-tier system of reserve remuneration that was in force from 30 October 2019 until 29 July 2022.[10] This tiered remuneration system exempted a portion of bank's excess reserve holdings at the Eurosystem's deposit facility from remuneration at the then applicable negative rate.[11] Up to that allowance, reserves were not remunerated, while for holdings in excess of the allowance the negative interest rate on the DFR was applicable. Therefore, banks with unused allowances had an incentive to borrow reserves in money markets at negative rates and deposit them in their central bank account, earning a wider spread, until they have exhausted their allowance in full. This additional demand for reserves by some banks could have had an upward pressure on short-term money market rates (Boucinha et al., 2022). The construction of this variable is explained in Section 4.2.

Next, we include in the model the equity market volatility index VIX_t which can capture general market uncertainty and also reflects shifts in market sentiment. Market volatility can affect money market interest rates via three channels. First, in conditions of elevated volatility, flight to safety can result in inflows into safe and liquid assets including repos and other money market instruments, affecting equilibrium money market interest rates irrespective of the LR. Second, bouts of volatility can tighten balance sheet constraints for banks operating under Value-at-Risk risk management frameworks, who in turn require a higher spread to absorb liquidity and re-deposit it with the Eurosystem. Third, and specific to the secured segments, volatility typically leads to increases in the term premia embedded in long-term bonds, which

[9] See previous literature for modelling approaches to estimate the relationship between central bank reserves and market interest rates (e.g., Veyrune et al., 2018; Afonso et al., 2022; Lopez-Salido and Vissing-Jorgensen, 2022).
[10] For details on two-tier system for remunerating excess reserve holdings, see: https://www.ecb.europa.eu/mopo/implement/mr/two-tier/html/index.en.html.
[11] More specifically the allowance amounted to 6 times each bank's minimum reserve requirements.

results *ceteris paribus* in lower market values of collateral, and collateral scarcity in turn manifests itself in lower repo rates all else equal.

In addition, we control for the year- and quarter-end effects with the corresponding dummy variables (y_end_t, q_end_t). These effects can be quite pronounced, especially for repo market rates, due to banks' balance sheet adjustments around reporting dates. The year-end effect tends to be stronger and reflects not only window-dressing aiming to improve regulatory LR requirements but also to minimize fees and levies determined at year-end (e.g., contribution to deposit insurance and resolution funds), linked to banks' balance sheet size. Lastly, to capture possible cross-border segmentation in money markets, we include a variable $domestic_{ibjt}$ that equals 1 when both the reporting bank and its counterparty to a particular transaction reside in the same country, and 0 otherwise. Banks could be inclined to offer better deposit rates in money markets to a counterparty located in the same jurisdiction, for various reasons (e.g., lower monitoring and transaction costs, home bias, among others).

Given that different money market segments have their own structure and characteristics, our model includes factors driving the spread that are common across all market segments, as well as control variables that are specific to each segment.

For the unsecured and secured OTC segments, we add the dummies capturing counterparty sectors and an indicator for location of the counterparty (EA versus non-EA). In addition, we control for trading relationships by including a relationship dummy (see Section 4.1 for details). Previous studies show that having an established trading relationship between the dealer and its OTC customer matters for the dealer's market power, consequently affecting prices and trade volumes in the repo market (e.g., Copeland et al. 2012; Li, 2021; Han et al., 2022; Eisenschmidt et al., 2024). For the secured OTC segment, we also control for the jurisdiction of the collateral issuer. For the secured CCP segment, the model includes the dummies controlling for the jurisdiction of the collateral issuer as well as for the jurisdiction of the CCP.

The model includes multiple fixed effects. μ_b are unobserved time-invariant bank-specific fixed effects, while ω_i denote unobserved time-invariant transaction pair-specific fixed effects, not captured by other variables already included in the model. ε_{ibjt} is an idiosyncratic error

term with mean 0 and variance $\sigma^2_{\varepsilon,ibjt}$.[12,13] Standard errors are clustered at the transaction-pair level to account for heteroscedasticity and autocorrelation in the error term.

4. Data description

4.1. Money market data

The study uses a panel dataset with daily data over the period from 2 January 2017 until 28 February 2023, combining granular information from different data sources. First, we obtain transaction-level data on banks' unsecured and secured borrowing from the Money Market Statistical Reporting (MMSR) database. It is a confidential, proprietary dataset available at the European Central Bank (ECB).[14] It collects all euro-denominated borrowing and lending money market transactions conducted by a sample of 52 banks from 10 EA countries. The MMSR dataset covers information on transaction volume, transaction interest rate, as well as the identity of the intermediating bank and some information about the counterparty, like their geographical location and sector. For the secured (collateralized) segment, the MMSR also reports the ISIN-level collateral specifications, such as amount, type of collateral, country, location, and sector of the issuer.

Our analysis focuses on both secured and unsecured segments. In the unsecured segment, we take transactions that contribute to the calculation of the €STR[15] - the unsecured overnight money market benchmark interest rate for the EA - prior to the application of the trimming procedure. These are overnight (O/N) transactions, conducted and settled on the previous business day (the reporting date "T") of the TARGET2 system in which large-value payments in the EA are processed, with a maturity date of "T+1". Following the methodology for the

[12] The transaction dyad *i* is defined as bank-counterparty-pairs. It captures a trading dyad between a bank X and a counterparty Y, for every transaction where this bank trades with this counterparty (irrespective of the volume). Thus, the same value of a transaction dyad (the same bank-counterparty pair) can repeat over time.
[13] We use the `reghdfe` command in STATA based on Correia (2017), which implements the linear fixed-effects regression estimator with high-dimensional fixed effects. The cross-sectional dimensions *i* (transaction dyad) and *b* (bank) are nested, i.e., multiple transactions are conducted with one bank. Therefore, transaction dyad-specific effects automatically control for bank-specific effects, which are absorbed in the estimation.
[14] For details on construction and documentation for the MMSR, see the information on the ECB website: https://www.ecb.europa.eu/stats/financial_markets_and_interest_rates/money_market/html/index.en.html.
[15] The euro short-term rate (€STR) is considered to be the Eurosystem's implicit operational target and is calculated based on MMSR data. The €STR reflects the wholesale euro unsecured overnight borrowing costs of banks located in the EA (For details, see: https://www.ecb.europa.eu/stats/financial_markets_and_interest_rates/euro_short-term_rate/html/index.en.html).

€STR calculation, we focus on unsecured fixed-rate deposit borrowing daily transactions with financial counterparties (excluding supranational entities and CCPs) that exceed EUR 1 million.

For the secured segment, we similarly limit the sample to very short-term (including O/N, spot-next S/N, and tomorrow-next T/N) borrowing transactions backed by General Collateral (GC). GC transactions are driven primarily by liquidity considerations, as they do not require a specific security to be pledged as collateral.

To make the secured segment more comparable to the unsecured one, we adopted some similar data selection criteria. Specifically, we keep fixed-rate deposit borrowing transactions of banks with financial counterparties, including CCPs, against collateral issued by entities located in the EA and representing central government or supranational institutions, and exceeding EUR 1 million. We split the resulting sample into the over-the-counter (OTC) and the CCP-cleared segments and conduct the analysis for each segment separately. The first one includes transactions of reporting banks directly with financial counterparties, while the second covers indirect transactions of banks with counterparties, cleared via the CCPs. In terms of the market share, the CCP-cleared segment accounts for about 60% of total daily borrowing volumes in the secured market, while the OTC segment – the remaining 40% of total daily volumes.

In order to construct a relationship dummy included in the baseline regression model (1), we identify the relationship links between reporting banks and their counterparties in a specific money market segment (unsecured or secured OTC) during the period analysed. In substance, a financial firm is considered to have a stable relationship with a bank if it regularly places a material share of its funds with that bank. 'Material' share is defined in terms of top percentiles in distribution of traded volumes, while 'regular' is defined in terms of a number of business days the bank-counterparty trade with each other. Two constellations are observed in the data. First, a counterparty could trade with more than one bank. In this case, it is important to identify which among the many interactions can be considered a stable and relevant relationship. We focus on the bank (or few banks) with which the counterparty trades significant amounts.[16] In

[16] As significant amounts from the perspective of the customer we consider cumulative transaction volumes (over the sample period) that belong to the top 10th percentile of the volume contribution vis-à-vis a specific bank in total cumulative transaction volumes (over the sample period) for that counterparty.

the second case - when a counterparty trades with only one bank - we consider a bank-counterparty pair to form a stable relationship if they transact cumulative volumes corresponding to the top 5% of cumulative market volumes. In addition, in both cases a bank-counterparty pair is treated as a relevant relationship if they trade on at least 120 business days (corresponding to roughly 6 months) over the sample period.[17]

For all three samples we winsorize the money market spread vis-à-vis the DFR at the 1st and 99th percentile of the sample distribution. In addition, given the very large and significantly more left-skewed dispersion of secured money market interest rates, we remove the bottom 5 percent of observations for the two secured segments. This approach prevents extreme values from affecting our results.

4.2. Additional explanatory variables

For each of the three money market segments, we combine the transaction-level data described above with quarterly information on banks' LRs obtained from supervisory reporting.[18]

Furthermore, we also include the bank-specific and aggregate ratio between excess liquidity (numerator) and total assets (denominator). Excess liquidity is defined as the surplus liquidity in the banking system surpassing the Eurosystem's minimum reserve requirements; it is calculated as the sum of reserves on the current account and the deposit facility minus the minimum reserve requirement and scaled by total assets. At aggregate level, excess liquidity captures the supply of liquidity by the central bank. For individual banks, it varies by business model and customer base of the respective institution and reflects both the supply of and demand for liquidity at individual bank level.

We also add bank-level information about the average unused tiering allowance for reserve remuneration at an interest rate of zero percent. More specifically, the bank's average unused allowances are calculated as the difference between the average (over the maintenance period) allowance (minimum reserve requirements times multiplier of 6) minus excess reserves held in

[17] The results are robust to using other, higher thresholds for a number of traded business days.
[18] The Common Reporting Framework (COREP) is the regulatory reporting framework of the European Banking Authority, introduced as part of the Capital Requirements Directive to standardize the reporting of capital requirements and prudential regulatory information by regulated investment firms and credit institutions across the EU.

banks' current account. This variable is set to zero whenever reserve holdings exceed the allowance as well as outside the tiering implementation period.

Finally, we add data capturing ECB's policy rates and financial variables - the level of the DFR and equity market volatility, more specifically the VIX index.[19] The latter captures uncertainty and reflects general market sentiment across different segments.

Table 1 shows the descriptive statistics of main variables for the three analysed samples (the descriptive statistics for all variables are shown in Tables A1-A3 in the Annex).

Table 1. Descriptive statistics – main variables

Variable	Mean	St. dev.	25th prct	75th prct
Unsecured segment				
Interest rate spread vis-à-vis DFR, in basis points	-6.27	8.73	-10.00	-5.00
Leverage ratio, in percent	4.53	1.27	3.84	4.86
Secured OTC segment				
Interest rate spread vis-à-vis DFR, in basis points	-9.15	9.36	-12.00	-4.00
Leverage ratio, in percent	5.95	0.99	5.09	6.74
Secured CCP segment				
Interest rate spread vis-à-vis DFR, in basis points	-13.13	7.95	-18.00	-8.00
Leverage ratio, in percent	4.89	0.62	4.52	5.21

Note: The table reports the descriptive statistics for main variables used in the regressions reported in Table 2, for each of the three segments: unsecured, secured OTC, and secured CCP-cleared. The mean, standard deviation (St.dev.), 25th and 75th percentiles are reported for the sample included in regressions. The number of observations for each segment: 425,103 (unsecured), 299,806 (secured OTC), 461,034 (secured CCP-cleared).

5. Empirical results

5.1. Main findings

Our main estimation results are included in Table 2. The baseline model shows that – in line with economic intuition - interest rate spreads in the unsecured and secured OTC segments significantly decrease in absolute value when the LR improves (i.e. they become less negative, as visible from the positive coefficient; Column 2). This implies that banks with a higher LR offer higher deposit rates to customers - reducing the spread to the DFR - compared to banks

[19] The VIX (Chicago Board Options Exchange Volatility Index) is a measure of the expected volatility of the U.S. stock market. While for the EA the VSTOXX based on EURO STOXX 50 would seem a more appropriate volatility measure, we chose to include the VIX as it is highly correlated with VSTOXX (correlation over 0.9) and gives a better overall fit in our model than VSTOXX.

with a lower LR. This finding is consistent with the hypothesis that banks which are closer to the regulatory minimum charge customers a higher intermediation spread for liquidity storage because it consumes already scarce balance sheet capacity. In terms of the economic significance, for the unsecured segment a one standard deviation increase in bank's LR – equal to 1.27 percentage points in this sample - is associated with a decline of the unsecured mark-down by about 1.1 basis points.[20] For the secured OTC segment a one standard deviation increase in the LR results in about 0.9 basis points lower (in absolute terms) spread to the DFR – a finding which is similar in its economic significance to the one for the unsecured segment.

By contrast, we find no significant effect of bank's LR on money market interest rates in the CCP-cleared segment. This could be explained by the fact that the LR calculation allows for netting of bilateral exposures for banks' securities financing transactions - repos and reverse repos – if conducted with qualified CCPs, subject to a few additional conditions.[21] In substance the netting implies that banks can finance the respective gross money market exposures with a (potentially significantly) smaller share of Tier 1 regulatory capital, thereby resulting in a lower implicit intermediation cost for trades that can be netted.

To further corroborate our results, we also zoom in on the period over which central bank reserves did not count towards banks' total exposures for the purpose of the LR calculation. Since over this period central bank reserves held on banks' accounts with the central bank did not result in a worsening of regulatory LRs, we would expect that the impact of the LR on money market spreads would be attenuated. Column 3 therefore includes a specification featuring an interaction term between the LR and a dummy equal to one during the exemption period (i.e., between Q2 2021 and Q1 2022).[22] Indeed, the results are in line with this reasoning: the effect of the bank's LR on the money market spreads declines during the exemption period - as visible from the negative coefficient on the interaction term – by about 80% for the unsecured segment and even stronger for the secured OTC segment.

[20] This corresponds to around 18% of the average level of the spread and 13% of its standard deviation over the sample period.
[21] See: https://www.bis.org/basel_framework/chapter/LEV/30.htm, recital 30.37; Grill et al. (2017) p. 161.
[22] ECB allows temporary relief in banks' leverage ratio after declaring exceptional circumstances due to pandemic (europa.eu)

Table 2. Baseline results: impact of leverage ratio and its exemption

	unsecured market			*secured market, OTC segment*			*secured market, CCP-cleared trades*		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Variables:	**baseline**	**with LR**	**interaction w. LR exemption period dummy**	**baseline**	**with LR**	**interaction w. LR exemption period dummy**	**baseline**	**with LR**	**interaction w. LR exemption period dummy**
Leverage ratio, lagged		0.887***	0.960***		0.924***	1.220***		-0.663	-1.207**
		(0.069)	(0.106)		(0.183)	(0.193)		(0.759)	(0.431)
LR exemption period dummy[1]			5.806***			16.50***			7.078**
			(0.531)			(0.868)			(2.578)
LR (lagged) * LR exemption period dummy			-0.788***			-1.797***			-0.618
			(0.113)			(0.130)			(0.528)
Bank-specific excess reserves, lagged,	-0.052***	-0.073***	-0.090***	0.126***	0.340***	0.316***	-0.035	-0.194	-0.157
in % of bank-specific TA	(0.015)	(0.016)	(0.016)	(0.044)	(0.032)	(0.026)	(0.105)	(0.174)	(0.146)
Aggregate EA excess reserves,	-0.565***	-0.567***	-0.823***	-1.717***	-2.516***	-3.290***	-0.743***	-0.329	-1.001***
in % of aggregate TA	(0.026)	(0.034)	(0.037)	(0.072)	(0.120)	(0.111)	(0.115)	(0.375)	(0.297)
Market volatility, VIX	0.025***	0.010**	0.024***	0.058***	-0.105***	-0.026***	0.028	-0.071	-0.025
	(0.005)	(0.004)	(0.004)	(0.010)	(0.008)	(0.006)	(0.041)	(0.062)	(0.054)
Year-end dummy	-1.093***	-1.038***	-1.127***	-7.155***	-8.560***	-9.124***	-3.731***	-4.643***	-4.910***
	(0.076)	(0.086)	(0.082)	(0.289)	(0.353)	(0.338)	(0.345)	(0.534)	(0.470)
Quarter-end dummy	0.200***	0.252***	0.069	-3.066***	-3.210***	-3.219***	-1.195***	-1.428***	-1.787***
	(0.041)	(0.044)	(0.043)	(0.135)	(0.155)	(0.140)	(0.157)	(0.235)	(0.172)
Relationship borrowing dummy	0.0390	-0.006	0.034	3.127***	0.976***	0.614***	-	-	-
	(0.257)	(0.304)	(0.299)	(0.296)	(0.170)	(0.129)			
Controls, common for all segments:	bank-specific: log of total assets, lagged; unused tiering exemption allowances, lagged; full set of bank fixed effects; transaction-specific: domestic trade dummy								
Sector-specific controls:	counterparty specific: counterparty sector dummies, counterparty location dummy (EA vs RoW); bank-counterparty-specific: relationship dummy						collateral-issuer dummies, ccp-specific dummies		
				collateral-issuer dummies					
Observations	570,599	425,103	425,103	444,079	299,806	299,806	917,633	461,034	461,034
R-squared	0.787	0.819	0.827	0.484	0.539	0.590	0.352	0.313	0.339

[1]Central bank reserves do not count towards the leverage ratio exposure measure

Notes: The table reports the estimation results of equation (1) where the spread between the transaction rate and the DFR (in basis points) in the corresponding market segment is a dependent variable. Constant, bank-fixed effects, additional controls are included (not shown). Standard errors in parentheses are clustered on the transaction dyad-level. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Regarding the control variables, the baseline analysis shows that aggregate EA excess liquidity – a factor controlled by the central bank - is an important driver of the negative spread between short-term money market rates and the DFR in all market segments. Two channels can in principle explain this finding. First, usually equilibrium interest rates in the money market tend to decline towards the DFR when the quantity of reserves supplied by the central bank increases. This channel operates for as long as central bank reserves are ample. The negative relationship disappears when the central bank saturates banks' liquidity needs fully (the 'liquidity trap' in Keynesian economics). Beyond that point, the second, and more relevant for

our analysis,[23] channel operates. Because warehousing deposits entails some operational costs and consumes balance sheet capacity, the lower bound for money market rates can be – and in fact is in our sample – lower than the DFR. With an increasing quantity of central bank reserves the balance sheet constraints of intermediating banks become progressively tighter and result in a very gradual but visible increase in the spread between money market rates and the DFR. Our coefficient on aggregate EA excess liquidity captures this effect. According to columns (1) of Table 2, an increase in aggregate excess reserves by 1 percent of total banking system assets (corresponding to roughly EUR 100 billion) results in widening of the mark-down to the DFR of around 0.5 basis points for the unsecured segment, a slightly larger – around 0.7 basis points – widening for the CCP-cleared secured money market spread, and is in the order of magnitude of about 2 basis points for OTC repos.[24] In principle, binding bank balance sheet constraints could impede EA banks' capacity to absorb excess liquidity from non-banks in the money market and result in large (and potentially volatile) spreads that interfere with the smooth transmission of policy rate changes. For our sample, this does not seem to be the case, visible in a relatively contained and predictable impact of excess reserve increases on the money market spreads to the DFR, with only the OTC segment being potentially a source of concern.

Moving to the remaining control variables, the coefficient on the relationship dummy is found to be positive and significant in the secured OTC segment where banks trade directly with their counterparties, mainly non-banks in our sample. These results suggest that banks offer better rates to counterparties with which they have an established trading relationship, compared to others. This outcome resonates with the findings of Eisenschmidt et al. (2024). The trading relationship with a counterparty does not seem to matter for banks' liquidity pricing in the unsecured segment.

Finally, in line with the pattern visible from Figure 1, money market interest rates exhibit downward spikes at year-end, which are almost 9 times larger in the secured OTC segment and

[23] This channel is more relevant because our sample covers a time period in which liquidity is abundant, a de-facto floor system for monetary policy implementation in the EA.
[24] The asset purchase programs conducted in the EA during the analyzed time period led to collateral scarcity in the repo markets, which spilled over also in the GC segment and resulted in particularly pronounced spreads. Since the netting of CCP-cleared repos seems to attenuate the impact of balance sheet constraints (as shown in our baseline results) this effect is strongly visible for the OTC segment.

4 times in the secured CCP-cleared segment than in the unsecured one. The quarter-ends have a significant dampening impact only on spreads in secured segments.

5.2. Extensions

In two extensions, discussed below, we test for non-linear effects and explore the role of the introduction of an add-on for systemically important banks in the LR requirement.

In Table 3 below we investigate whether the impact of the regulatory LRs on banks' money market borrowing spreads increases progressively when LRs decline towards the regulatory minimum. Previous studies find that banks with a LR closer to the regulatory minimum reduce their money market borrowing more strongly than banks with larger buffers (Bucalossi and Scalia, 2016; Grill et al., 2017; Corradin et al., 2020). We test if it also holds for money market interest rates. We consider two potential thresholds for the LR: the *Low LR dummy* takes the value 1 when the LR is below 4%, and *Very low LR dummy* – when it is below 3.5%, and 0 otherwise. These thresholds are based on the distribution of the LR across our sample of banks, where the bottom 25th percentile is chosen to indicate low LR and the bottom 10th percentile – very low LR. We expect that banks with (very) low LR will be more inclined to reduce their balance sheets, consequently offering lower and thus much less attractive deposit rates to customers and accordingly wider spreads.

In line with our conjecture, Table 3, column (1) shows that banks with a low LR offer on average 0.8 basis points lower overnight deposit rates in the unsecured money market compared to banks which have the LR above this threshold. For the secured OTC segment, the difference increases to 1.2 basis points. This effect becomes even stronger when the LR level is closer to the regulatory minimum, i.e. below the threshold of 3.5% (column (3)) and becomes visible also for the CCP-cleared segment. Importantly, the threshold effect for banks with very low LR continues being statistically significant and economically meaningful in terms of size for both unsecured and CCP-cleared secured segments also when controlling for the level of the LR in the same specification. By contrast, in the secured OTC segment the evidence for non-linear effects is less convincing as the low LR dummy loses significance after the inclusion of the LR.

Table 3. Effects of low and very low leverage ratio threshold

	unsecured market				*secured market, OTC segment*				*secured market, CCP segment*			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	low	low	very low	very low	low	low	very low	very low	low	low	very low	very low
Variables:	LR dummy	LR dummy	LR dummy	LR dummy	LR dummy	LR dummy	LR dummy	LR dummy	LR dummy	LR dummy	LR dummy	LR dummy
Leverage ratio, lagged		0.840***		0.840***		0.937***		0.943***		-0.566		-0.667
		(0.073)		(0.069)		(0.210)		(0.186)		(0.926)		(0.761)
Low LR dummy	-0.821***	-0.223*			-1.197**	0.106			1.278	0.667		
	(0.115)	(0.122)			(0.477)	(0.568)			(1.286)	(1.653)		
Very low LR dummy			-1.046***	-0.597***			-1.064	0.819			-4.640**	-6.197**
			(0.144)	(0.143)			(0.718)	(0.692)			(1.727)	(2.770)
Bank-specific excess reserves, lagged,	-0.102***	-0.0760***	-0.0799***	-0.065***	0.324***	0.341***	0.334***	0.340***	-0.192	-0.195	-0.187	-0.194
in % of bank-specific TA	(-0.016)	(-0.016)	(-0.016)	(-0.016)	(0.034)	(0.034)	(0.032)	(0.032)	(0.166)	(0.170)	(0.173)	(0.174)
Aggregate EA excess reserves,	-0.458***	-0.567***	-0.489***	-0.593***	-2.314***	-2.517***	-2.285***	-2.518***	-0.348	-0.319	-0.382	-0.329
in % of aggregate TA	(0.031)	(0.034)	(0.033)	(0.035)	(0.087)	(0.120)	(0.083)	(0.120)	(0.345)	(0.348)	(0.399)	(0.375)
Market volatility, VIX	0.011**	0.010**	0.011**	0.008**	-0.114***	-0.105***	-0.116***	-0.104***	-0,072	-0,073	-0.068	-0.071
	(0.004)	(0.004)	(0.004)	(0.004)	(0.009)	(0.008)	(0.009)	(0.008)	(0.063)	(0.064)	(0.060)	(0.062)
Year-end dummy	-1.097***	-1.047***	-1.081***	-1.046***	-8.413***	-8.563***	-8.432***	-8.564***	-4.725***	-4.665***	-4.699***	-4.643***
	(0.087)	(0.086)	(0.087)	(0.086)	(0.344)	(0.358)	(0.343)	(0.354)	(0.536)	(0.558)	(0.526)	(0.535)
Quarter-end dummy	0.313***	0.252***	0.324***	0.255***	-3.212***	-3.210***	-3.215***	-3.210***	-1.456***	-1.442***	-1.429***	-1.428***
	(0.044)	(0.044)	(0.045)	(0.044)	(0.156)	(0.155)	(0.157)	(0.155)	(0.224)	(0.233)	(0.233)	(0.235)
Relationship borrowing dummy	-0.091	-0.015	-0.073	-0.010	0.992***	0.976***	0.991***	0.977***	-	-	-	-
	(0.310)	(0.304)	(0.309)	(0.304)	(0.170)	(0.170)	(0.170)	(0.170)				
Controls, common for all segments:	bank-specific: log of total assets, lagged; unused tiering exemption allowances, lagged; full set of bank fixed effects; transaction-specific: domestic trade dummy											
Sector-specific controls:	counterparty specific: counterparty sector dummies, counterparty location dummy (EA vs RoW); bank-counterparty-specific: relationship dummy								collateral-issuer dummies, ccp-specific dummies			
					collateral-issuer dummies							
Observations	425,103	425,103	425,103	425,103	299,806	299,806	299,806	299,806	461,034	461,034	461,034	461,034
R-squared	0.816	0.819	0.816	0.819	0.538	0.539	0.537	0.539	0.312	0.313	0.312	0.313

Notes: The table reports the estimation results of equation (1) where the spread between the transaction rate and DFR (in basis points) in the corresponding market segment is a dependent variable. Constant, bank-fixed effects, additional controls are included (not shown). Standard errors in parentheses are clustered on the transaction dyad-level. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Next, we examine the role of a more stringent LR requirement – implemented by means of introducing an add-on for G-SIBs on top of the minimum requirement applicable for other banks (see Section 2 for details). In principle this add-on would imply that G-SIBs need to back a higher share of their central bank reserve holdings with relatively expensive Tier 1 capital compared with other banks.[25] Since the balance sheet costs of warehousing central bank reserves increase for G-SIBs, we would expect that money market interest rates for this group of banks are more sensitive to changes in the respective bank-specific LR.

To investigate whether indeed the impact of the LR on money market interest rates differs for G-SIBs compared to other banks, we construct two dummy variables. A GSIB dummy takes the value 1 if the bank in our sample was included in the 2022 Basel list of G-SIBs,[26] and 0 otherwise. Our second dummy – labelled GSIB-announcement - takes the value 1 from the announcement date of the G-SIB add-on in the LR (i.e., from 27 March 2020), and is set at 0 before. In the regression model, we interact the GSIB-dummy with the bank's LR to test whether the impact of the regulatory LR differs between G-SIB and non-GSIB banks. Second, we add an interaction term of the GSIB dummy with the GSIB-announcement dummy and examine the role of announcement effects with the introduction having been largely anticipated before the announcement.

Our findings (Table 4, column (1)) show that G-SIBs with lower LRs offer deposit rates that are respectively 0.4 and 5 basis points lower compared to the terms offered by non-GSIBs with a similar LR level in the unsecured and secured OTC segments, respectively. Thus, the existence of an add-on makes G-SIBs more sensitive in adjusting the rates for borrowed liquidity in money markets. This effect is stronger in the post-announcement period (column (2)) for the secured OTC segment. The results for the CCP-cleared segment once controlling for the announcement appear counterintuitive.

[25] Violon et al. (2020) show that financial regulation substantially slowed down the expansion of the balance sheet of G-SIBs, which improved their LR.
[26] 2022 List of Global Systemically Important Banks (G-SIBs) - Financial Stability Board.

Table 4. Effects of leverage ratio conditional on G-SIBs regulation

	unsecured market		*secured market, OTC segment*		*secured market, CCP-cleared trades*	
	(1)	(2)	(1)	(2)	(1)	(2)
Variables:	**GSIB dummy**	**with GSIB announcement**	**GSIB dummy**	**with GSIB announcement**	**GSIB dummy**	**with GSIB announcement**
Leverage ratio, lagged	0.845***	0.846***	0.898***	-0.233	-0.352	-1.363***
	(0.069)	(0.093)	(0.185)	(0.183)	(0.572)	(0.077)
LR (lagged)*GSIB dummy	0.478**	0.457*	5.822***	5.623***	-4.574	-2.522***
	(0.225)	(0.254)	(1.588)	(1.559)	(2.984)	(0.280)
LR (lagged)*GSIB dummy*GSIB announcement		0.055		2.818***		1.306***
		(0.092)		(0.279)		(0.340)
Bank-specific excess reserves, lagged,	-0.074***	-0.071***	0.339***	0.102***	-0.207	-0.091***
in % of bank-specific TA	(0.016)	(0.017)	(0.032)	(0.0323)	(0.165)	(0.016)
Aggregate EA excess reserves,	-0.566***	-0.593***	-2.515***	-3.686***	-0.307	-2.266***
in % of aggregate TA	(0.034)	(0.049)	(0.120)	(0.110)	(0.375)	(0.053)
Market volatility, VIX	0.010**	0.010**	-0.105***	-0.148***	-0.060	-0.098***
	(0.004)	(0.004)	(0.008)	(0.008)	(0.052)	(0.004)
Year-end dummy	-1.052***	-1.059***	-8.557***	-9.225***	-4.705***	-5.220***
	(0.087)	(0.084)	(0.353)	(0.355)	(0.562)	(0.113)
Quarter-end dummy	0.249***	0.237***	-3.217***	-3.310***	-1.470***	-2.046***
	(0.044)	(0.047)	(0.155)	(0.141)	(0.269)	(0.058)
Relationship borrowing dummy	-0.010	-0.012	0.979***	0.636***	-	-
	(0.304)	(0.303)	(0.170)	(0.151)		
Controls, common for all segments:	bank-specific: log of total assets, lagged; unused tiering exemption allowances, lagged; full set of bank fixed effects; transaction-specific: domestic trade dummy					
Sector-specific controls:	counterparty specific: counterparty sector dummies, counterparty location dummy (EA vs RoW); bank-counterparty-specific: relationship dummy				collateral-issuer dummies, ccp-specific dummies	
			collateral-issuer dummies			
Observations	425,103	425,103	299,806	299,806	461,034	461,034
R-squared	0.827	0.827	0.539	0.573	0.316	0.354

Notes: The table reports the estimation results of equation (1) where the spread between the transaction rate and DFR (in basis points) in the corresponding market segment is a dependent variable. Constant, bank-fixed effects, additional controls are included (not shown). Standard errors in parentheses are clustered on the transaction dyad-level. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

6. Conclusions

This paper investigates the impact of the regulatory LR on banks' demand for reserves and thus the pricing of overnight liquidity in the EA money markets, using MMSR data between January 2017 - February 2023 in the two major overnight money market segments – the unsecured and the secured one, distinguishing between OTC and CCP-cleared trades for the latter. We contribute to the literature by exploring several potential factors that may influence the direct effect of the LR on money market spreads. Specifically, we consider the role of the LR

exemption during the pandemic, banks' distance to the minimum LR requirement, their size, and the role of netting of bilateral exposures for CCP-cleared money market trades.

Our findings confirm the existence of a significant positive link between a bank's LR and the spread between its money market borrowing rate and the DFR, in the unsecured and secured OTC segments. That is, banks with a higher LR offer higher deposit rates to customers, thereby reducing the spread. The impact appears to be stronger for G-SIBs, likely due to an add-on on top of the regulatory LR requirement for these banks, and weaker for CCP-cleared trades compared to secured OTC transactions, probably reflecting netting that can effectively allow banks to finance the respective gross money market exposures with a smaller share of Tier 1 capital. Moreover, the impact of the LR is dampened during the period in which central bank reserves did not count towards the LR exposure measure. This suggests that the temporary LR relief during the pandemic supported the implementation of monetary policy as intended. Finally, we find evidence of non-linear effects: a decline in the LR for banks operating close to the regulatory minimum results in an over-proportional widening of the spread between the money market deposit rates they offer vis-à-vis the DFR.

Our findings are informative also from a policy perspective. First, regulatory measures such as the LR can have a significant impact on banks' demand for reserves, with implications for money market activity. Second, the LR exemption during the pandemic was successful in providing some relief for banks and supporting their money market intermediation role. Third, the regulatory LR may have varying effects across banks and money market segments, resulting in differences in banks' demand for reserves.

References

Aberg, P., M. Corsi, V. Grossmann-Wirth, T. Hudepohl, Y. Mudde, T. Rosolin, and F. Schobert (2021). Demand for central bank reserves and monetary policy implementation frameworks: the case of the Eurosystem. Occasional Paper Series 282, European Central Bank.

Acharya, V., R. S. Chauhan, R. G. Rajan, and S. Steffen (2022). Liquidity dependence: why shrinking central bank balance sheets is an uphill task. Federal Reserve Bank of Kansas Jackson Hole Economic Symposium in August 2022.

Afonso, G., R. Armenter, and B. Lester (2019). A model of the federal funds market: yesterday, today, and tomorrow. *Review of Economic Dynamics*, 33, 177-204.

Afonso, G., D. Giannone, G. La Spada, and J. C. Williams (2022). Scarce, abundant, or ample? A time-varying model of the reserve demand curve. FRB of New York Staff Report No. 1019.

Allahrakha, M., J. Cetina, and B. Munyan (2018). Do higher capital standards always reduce bank risk? The impact of the Basel leverage ratio on the US triparty repo market. *Journal of Financial Intermediation*, 34, 3-16.

Anbil, S. and Z. Senyuz (2022). How has monetary and regulatory policy affected trading relationships in the U.S. repo market? *International Journal of Central Banking*, 18(4), 1-52.

Baldo, L., A. Bucalossi, and A. Scalia (2018). Leverage ratio and central bank operations in the euro area. *Economic Notes*, 47 (1), 21-68.

Banegas, A. and M. Tase (2020). Reserve balances, the federal funds market and arbitrage in the new regulatory framework. *Journal of Banking & Finance*, 118, 105893.

Bassi, C., M. Behn, M. Grill, and M. Waibel (2024). Window dressing of regulatory metrics: evidence from repo markets. *Journal of Financial Intermediation*, 58, 101086.

BIS (2014). Basel III leverage ratio framework and disclosure requirements. Basel Committee on Banking Supervision, Bank for International Settlements.

BIS (2023). LEV40. Leverage ratio requirements for global systemically important banks. Bank for International Settlements.

Boucinha, M., L. Burlon, M. Corsi, G. della Valle, J. Eisenschmidt, I. Marmara, S. Pool, J. Schumacher, and O. Vergote (2022). Two-tier system for remunerating excess reserve holdings. ECB Occasional Paper No. 2022/302, European Central Bank.

Bucalossi, A. and A. Scania (2016). Leverage ratio, central bank operations and repo market. Banca d'Italia Occasional Paper No 347, Bank of Italy.

Copeland, A., D. Duffie, A. Martin, and S. McLaughlin (2012). Key mechanics of the US triparty repo market. Federal Reserve Bank of New York Economic Policy Review 18 (3), 17-28.

Corradin, S., J. Eisenschmidt, M. Hoerova, T. Linzert, G. Schepens, and J-D. Sigaux (2020). Money markets, central bank balance sheet and regulation. ECB Working Paper Series 2483, European Central Bank.

Correia, S. (2017). Linear models with high-dimensional fixed effects: an efficient and feasible estimator. Working Paper. https://scorreia.com/research/hdfe.pdf.

Eisenschmidt, J., Y. Ma, and A. L. Zhang (2024). Monetary policy transmission in segmented markets. *Journal of Financial Economics*, 151, 103738.

Grill, M., J. Jakovicka, C. Lambert, P. Nicoloso, L. Steininger, and M. Wedow (2017). Recent developments in euro area repo markets, regulatory reforms and their impact on repo market functioning. Financial Stability Review November 2017 – Special Features.

Han, S., K. Nikolaou, and M. Tase (2022). Trading relationships in secured markets: Evidence from triparty repos. *Journal of Banking & Finance*, 139, 106486.

Kim, K., A. Martin, and E. Nosal (2020). Can the U.S. interbank market be revived?, *Journal of Money, Credit and Banking*, 52(7), 1645-1689.

Kotidis, A. and N. van Horen (2018). Repo market functioning: The role of capital regulation. Staff Working Paper No. 746, Bank of England.

Li, Y. (2021). Reciprocal lending relationships in shadow banking. *Journal of Financial Economics,* 141(2), 600-619.

Lopez-Salido, D., and A. Vissing-Jorgensen (2022). Reserve demand and balance-sheet runoff. Working Paper. Board of Governors of the Federal Reserve System

Munyan, B. (2017). Regulatory arbitrage in repo markets. Office of Financial Research Working Paper (15-22).

Ranaldo, A., P. Schaffner, and M. Vasios (2021). Regulatory effects on short-term interest rates. *Journal of Financial Economics*, 141(2), 750-770.

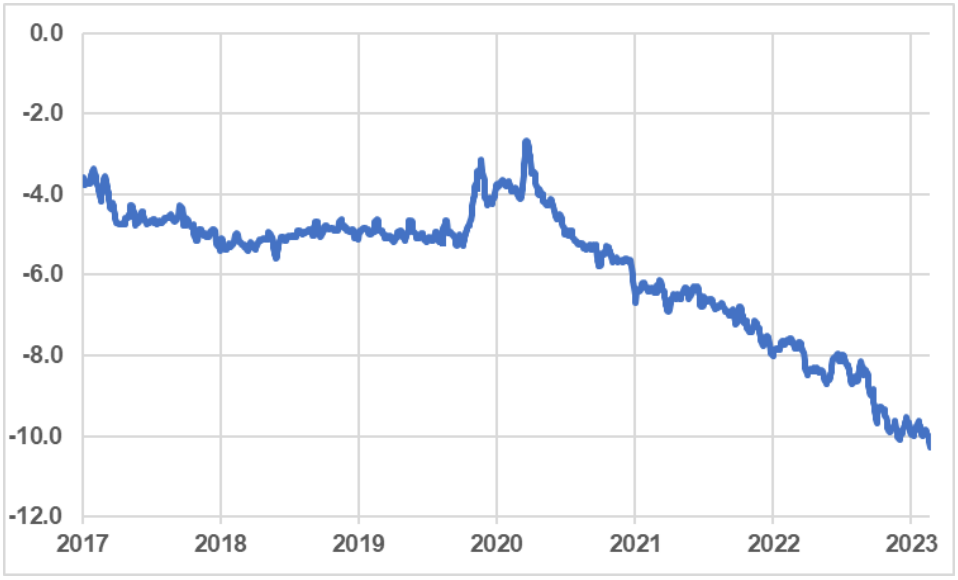
Stulz, R.M, A.G. Taboada, and M. A. van Dijk (2022). The determinants of bank liquid asset holdings. NBER Working Papers 30340, National Bureau of Economic Research.

Veyrune, R. M., G. della Valle, and S. Guo (2018). Relationship between short-term interest rates and excess reserves: a logistic approach, IMF Working Papers 18/80, International Monetary Fund.

Violon, A., D Durant, and O. Toader (2020). The impact of the designation of global systemically important banks on their business model. *International Journal of Central Banking,* 16(5), 95-142.

Annex

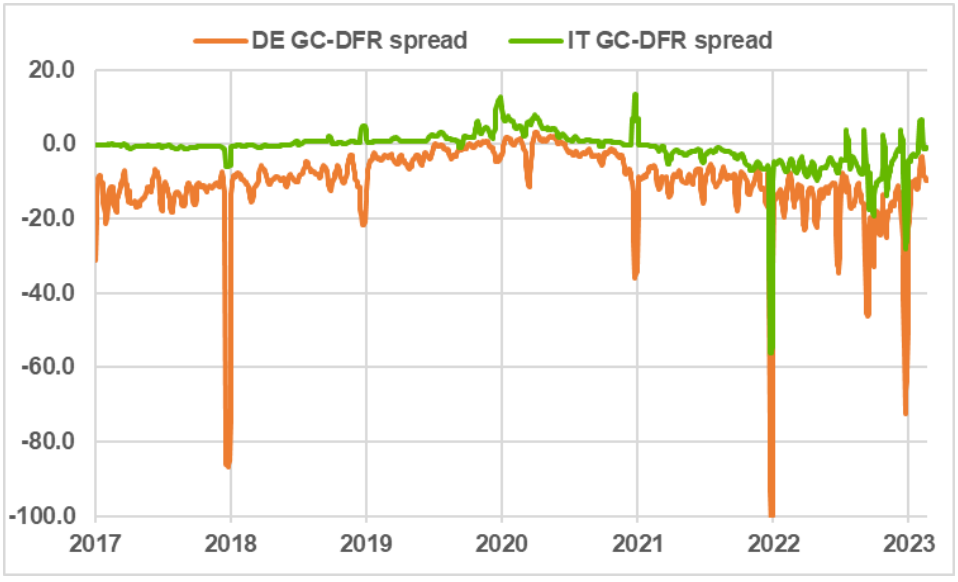
Figure A1. €STR-DFR spread (in basis points), January 2017 - February 2023



Source: MTS/Brokertec, ECB, and ECB calculations.

Notes: Rates are determined on the basis of the agreement date of relevant transactions and calculated as the volume weighted average daily rate. Spreads are the difference between the daily €STR and the DFR, smoothed as a 7-day moving average. Last observation: 28 February 2023.

Figure A2. Repo rate spreads vis-à-vis the DFR (in basis points), January 2017 - February 2023



Source: MTS/Brokertec, ECB, and ECB calculations.

Notes: Rates are determined on the basis of the agreement date of relevant transactions and calculated as the volume weighted average daily rate. Spreads are the differences between the daily repo rates and the DFR, smoothed as a 7-day moving average. DE GC and IT GC rates are rates for secured market transactions backed by German and Italian General collateral, respectively. Last observation: 28 February 2023.

Table A1. Descriptive statistics, unsecured segment

Variable	Mean	St. dev.	25th prct	75th prct
Spread, in basis points	-6.27	8.73	-10.00	-5.00
Leverage ratio (LR), in percentage	4.53	1.27	3.84	4.86
Aggregate EL/total banking system assets, in percentage	8.54	2.72	5.85	11.47
Bank-specific excess liquidity/total assets, in percentage	8.89	4.93	5.30	11.92
Bank-specific total assets, in log-level	6.11	0.77	5.55	6.50
Average unused tiered remuneration allowances, in EUR bln	0.055	1.012	0.00	0.00
Market volatility (VIX index)	18.10	7.61	13.06	21.59
Year-end dummy	0.03	0.16	0.00	0.00
Quarter-end dummy	0.03	0.16	0.00	0.00
Relationship borrowing dummy	0.14	0.35	0.00	0.00
Domestic transaction dummy	0.25	0.43	0.00	0.00
Location category of reporting bank (EA or non-EA)	1.19	0.39	1.00	1.00
LR exemption period dummy	0.29	0.45	0.00	1.00
Low LR dummy	0.33	0.47	0.00	1.00
Very low LR dummy	0.11	0.31	0.00	0.00
G-SIB definition dummy	0.40	0.49	0.00	1.00
G-SIB announcement dummy	0.56	0.50	0.00	1.00
Counterparty dummy – insurance companies & pension funds	0.09	0.29	0.00	0.00
Counterparty dummy – money market funds	0.16	0.36	0.00	0.00
Counterparty dummy – investment funds	0.46	0.50	0.00	1.00
Counterparty dummy – other financial institutions	0.15	0.36	0.00	0.00
Counterparty dummy – non-EA monetary financial institutions	0.10	0.30	0.00	0.00

Note: The table reports the descriptive statistics for all variables included in the estimated regressions reported in Tables 2-5, for unsecured market segment. The mean, standard deviation (St.dev.), 25th and 75th percentiles are reported for the sample included in these regressions. The number of observations: 425,103.

Table A2. Descriptive statistics, secured OTC segment

Variable	Mean	St. dev.	25th prct	75th prct
Spread, in basis points	-9.15	9.36	-12.00	-4.00
Leverage ratio (LR), in percentage	5.95	0.99	5.09	6.74
Aggregate EL/total banking system assets, in percentage	9.55	2.49	6.20	11.63
Bank-specific excess liquidity/total assets, in percentage	8.73	4.49	5.22	12.09
Bank-specific total assets, in log-level	5.91	0.37	5.78	6.14
Average unused tiered remuneration allowances, in EUR bln	0.03	0.48	0.00	0.00
Market volatility (VIX index)	18.76	6.53	14.20	22.44
Year-end dummy	0.03	0.17	0.00	0.00
Quarter-end dummy	0.04	0.19	0.00	0.00
Relationship borrowing dummy	0.22	0.42	0.00	0.00
Domestic transaction dummy	0.92	0.27	1.00	1.00
Location category of reporting bank (non-EA dummy)	0.05	0.22	0.00	0.00
LR exemption period dummy	0.50	0.50	0.00	1.00
Low LR dummy	0.03	0.16	0.00	0.00
Very low LR dummy	0.002	0.05	0.00	0.00
G-SIB definition dummy	0.04	0.19	0.00	0.00
G-SIB announcement dummy	0.74	0.44	0.00	1.00
Counterparty dummy – insurance companies & pension funds	0.27	0.44	0.00	1.00
Counterparty dummy – money market funds	0.15	0.36	0.00	0.00
Counterparty dummy – non-MMF investment funds	0.43	0.50	0.00	1.00
Counterparty dummy – other financial institutions	0.01	0.08	0.00	0.00
Counterparty dummy – non-EA monetary financial institutions	0.02	0.12	0.00	0.00
German collateral dummy	0.01	0.10	0.00	0.00
Italian collateral dummy	0.02	0.14	0.00	0.00
Spanish collateral dummy	0.73	0.44	0.00	1.00
French collateral dummy	0.17	0.38	0.00	0.00
Rest-of-EA collateral dummy	0.05	0.21	0.00	0.00

Note: The table reports the descriptive statistics for all variables included in the estimated regressions reported in Tables 2-5, for secured OTC segment. The mean, standard deviation (St.dev.), 25th and 75th percentiles are reported for the sample included in these regressions. The number of observations: 299,806.

Table A3. Descriptive statistics, secured CCP-cleared segment

Variable	Mean	St. dev.	25th prct	75th prct
Spread, in basis points	-13.13	7.95	-18.00	-8.00
Leverage ratio (LR), in percentage	4.89	0.62	4.52	5.21
Aggregate EL/total banking system assets, in percentage	9.42	2.63	6.02	11.59
Bank-specific excess liquidity/total assets, in percentage	12.34	4.98	8.58	16.51
Bank-specific total assets, in log-level	5.87	0.47	5.46	6.17
Average unused tiered remuneration allowances, in EUR bln	0.03	0.39	0.00	0.00
Market volatility (VIX index)	18.52	7.53	13.69	22.39
Year-end dummy	0.01	0.12	0.00	0.00
Quarter-end dummy	0.03	0.16	0.00	0.00
Domestic transaction dummy	0.12	0.33	1.00	1.00
LR exemption period dummy	0.39	0.49	0.00	1.00
Low LR dummy	0.07	0.25	0.00	0.00
Very low LR dummy	0.00005	0.01	0.00	0.00
G-SIB definition dummy	0.26	0.44	0.00	1.00
G-SIB announcement dummy	0.70	0.46	0.00	1.00
Legal jurisdiction Germany, CCP dummy	0.01	0.10	0.00	0.00
Legal jurisdiction Spain, CCP dummy	0.0005	0.02	0.00	0.00
Legal jurisdiction France, CCP dummy	0.89	0.32	1.00	1.00
Legal jurisdiction UK, CCP dummy	0.10	0.30	0.00	0.00
Legal jurisdiction Italy, CCP dummy	0.0005	0.02	0.00	0.00
German collateral dummy	0.19	0.39	0.00	0.00
Italian collateral dummy	0.14	0.35	0.00	0.00
Spanish collateral dummy	0.25	0.43	0.00	1.00
French collateral dummy	0.20	0.40	0.00	0.00
Rest-of-EA collateral dummy	0.22	0.42	0.00	0.00

Note: The table reports the descriptive statistics for all variables included in the estimated regressions reported in Tables 2-5, for secured CCP-cleared segment. The mean, standard deviation (St.dev.), 25th and 75th percentiles are reported for the sample included in these regressions. The number of observations: 461,034.

Acknowledgements

We thank Maarten Groenen, Federic Holm-Hadulla, Jan Kakes, Yvo Mudde, and the participants of the ECB research seminar for useful comments and suggestions. Anna Samarina worked on this paper during her virtual secondment at the European Central Bank (ECB), while Lara Sousa Faria was involved during her traineeship at the ECB.
The views expressed are those of the authors and do not necessarily reflect the official views of De Nederlandsche Bank, the ECB or the Eurosystem.

Desislava Andreeva
European Central Bank, Frankfurt am Main, Germany; email: desislava.andreeva@ecb.europa.eu

Anna Samarina
De Nederlandsche Bank, Amsterdam, The Netherlands; University of Groningen, Groningen, The Netherlands;
email: a.samarina@dnb.nl

Lara Sousa Faria
NOVA Information Management School, Lisboa, Portugal: email: fariasousalara@gmail.com

PDF ISBN 978-92-899- 7006-8 ISSN 1725-2806 doi:10.2866/ 7485779 QB-01-25-029-EN-N